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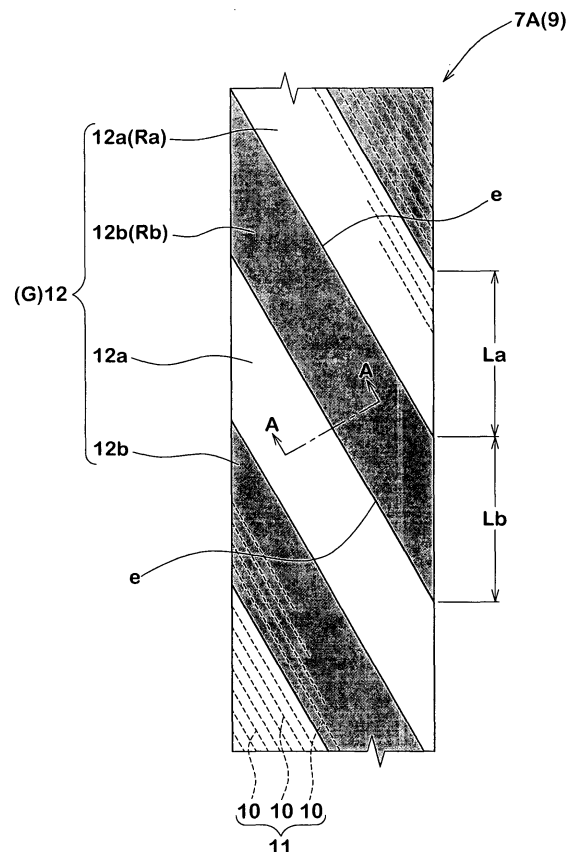
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(54) **Pneumatic tire**

(57) A pneumatic tire (1) comprises

a carcass (6) extending between bead portions (4) through a tread portion (2) and sidewall portions (3) and
a belt (7) disposed radially outside the carcass in the tread portion, said belt comprising at least one belt ply (7A,7B) made of parallel cords (10,11) embedded in a composite topping rubber layer (G,12),
said composite topping rubber layer formed at least two kinds of topping rubbers (12a,12b) having different complex elastic moduli, and
said topping rubbers alternately disposed in a circumferential direction of the tire.

FIG.2



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a pneumatic tire in which uniformity can be enhanced.

Description of the Related Art

[0002] In recent years, higher uniformity is required for tires. Especially, a tractive force variation ("TFV", hereinafter) that is a variation component of force in a longitudinal direction at the time of rotation, and a radial force variation ("RFV", hereinafter) that is a variation component of force in a radial direction of the tire cause vibration and noise at the time of running. Therefore, it is desired to reduce such force variations as small as possible.

[0003] Conventionally, in order to enhance the uniformity of a tire, there is proposed a pitch variation method for dispersing pitch arrangement in a tread pattern of the tire. There is also proposed a method for dispersing joint portions of tire constituent members such as a carcass ply and a belt ply so that the joint portions are not overlapped.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to enhance the uniformity from a different view point from those of conventional techniques. In accordance with the present invention a pneumatic tire comprises:

a carcass extending between bead portions through a tread portion and sidewall portions; and
a belt disposed radially outside the carcass in the tread portion, said belt comprising
at least one belt ply made of parallel cords embedded in a composite topping rubber layer,
said composite topping rubber layer formed at least two kinds of topping rubbers having different complex elastic
moduli and said topping rubbers alternately disposed in a circumferential direction of the tire.

[0005] Such a belt ply having the composite topping rubber layer disperses rigidity of the belt ply in the circumferential direction of the tire, and enhances the uniformity, especially the TFV at the time of high speed running.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Fig. 1 is a sectional view of a pneumatic tire showing an embodiment of the present invention;
Fig. 2 is a developed view of one belt ply;
Fig. 3 is a sectional view taken on line A-A in Fig. 2;
Fig. 4 is a developed view of a belt;
Fig. 5 is a plan view showing one example of a producing process of a belt ply; and
Fig. 6 corresponds to a sectional view taken on line A-A in Fig. 2 showing another embodiment of a belt ply having a composite topping rubber layer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0007] In the drawings, a pneumatic tire 1 according to the present invention comprises a tread portion 2, a pair of sidewall portions 3, a pair of bead portions 4, a carcass 6 extending between the bead portions 4 through the tread portion 2 and sidewall portions 3, a belt 7 disposed radially outside the carcass 6 in the tread portion 2. The tire 1 in this embodiment is a tubeless radial tire for a passenger car.

[0008] The carcass 6 comprises at least one ply, in this embodiment only one ply 6A, of radially arranged carcass cords extending between the bead portions 4 through the tread portion 2 and sidewall portions 3 and turned up around the bead cores 5 from the axially inside to outside of the tire to be secured thereto and to form a pair of turnup portions 6b and a main portion 6a therebetween. The cords are arranged at a certain angle in the range of from 80 to 90 degrees with respect to the tire equator C. For the carcass cords, organic fiber cords, e.g. polyester, nylon, rayon, aramid and the like are preferably used. However, steel cords can also be used.

[0009] Between the turnup portion 6b and main portion 6a in each bead portions 4, a bead apex 8 is disposed and extends taperingly radially outwards from the bead core 5. The bead apex 8 is made of a hard rubber compound

preferably having a JIS-A hardness of 80 to 98 degrees.

[0010] The belt 7 comprises at least one belt ply, preferably two belt plies 7A and 7B as shown in Fig. 1. Fig. 2 is a developed view of the one belt ply 7A. The belt ply 7A comprises a plurality of parallel belt cords 11 inclined with respect to a circumferential direction of the tire, and a topping rubber layer G in which the belt cords 11 are embedded.

[0011] In this embodiment, steel cords are employed as the belt cords 10. As the steel cords, it is possible to use various cords, such as solid wires, stranded wires, or a plurality of wires bundle in parallel to one another. In addition to the steel cords, it is possible to employ organic fiber cords having high elasticity such as aromatic polyamide, rayon and the like.

[0012] The belt cords 10 are inclined with respect to the tire equator C through about 10 to 35°. As shown in Fig. 4, the belt plies 7A and 7B are arranged in a direction in which the cords intersect with each other. The belt ply 7A arranged radially inside of the tire is wider than the belt ply 7B, and widthwise centers of both the plies 7A and 7B are substantially aligned to each other.

[0013] At least one of the belt plies 7A and 7B of the belt 7 comprises a belt ply 9 having a composite topping rubber layer 12. In this embodiment, each of the belt plies 7A and 7B comprises the belt ply 9 having the layer 12.

[0014] As shown in Fig. 2, the composite topping rubber layer 12 formed at least two kinds of topping rubbers having different complex elastic moduli and alternately arranged in the circumferential direction of the tire. The composite layer 12 of this embodiment comprises a first topping portion 12a made of a first topping rubber Ra and a second topping portion 12b made of a second topping rubber Rb having greater complex elastic modulus than that of the first topping rubber Ra. The first topping portion 12a and the second topping portion 12b are alternately arranged in the circumferential direction of the tire. That is, in this embodiment, there are two kinds of topping rubbers.

[0015] Each of the first topping portion 12a and the second topping portion 12b are formed into substantially parallelogram having a pair of parallel sides e, e extending along the cords 11. The first and second topping portions 12a and 12b form the topping rubber layer 12 which continuously extends in the circumferential direction of the tire through a joint at which the sides e and e thereof are jointed to each other.

[0016] As is apparent from Fig. 3, the topping rubber layer 12 of this embodiment has an enough thickness to completely cover the belt cords 11. In other words, a thickness t of the topping rubber layer 12 is greater than an outer diameter tc of the belt cord 10. However, the manner in which the topping rubber layer 12 covers the belt cords 11 is not limited to that shown in the drawing.

[0017] The thickness t of the topping rubber layer 12 is preferably about 1.0 to 2.0 times the outer diameter tc of the belt cord 10. This thickness t may be constant or varied. The cross sections of the belt plies 7A and 7B are usually finished to the shape as shown in Fig. 3 by crimping thin rubber sheets on both side surfaces of the belt cords 11. In this embodiment, the first topping portion 12a and the second topping portion 12b constitute the entire thickness as measured from the upper surface to the lower surface of the belt ply 9.

[0018] In the composite topping rubber layer 12, rubber portions of different rigidities appear alternately in the circumferential direction of the tire. The belt ply 9 having the composite rubber layer 12 provides rigidity variation in which a high rigidity portion and a low rigidity portion are dispersed in the circumferential direction. This reduces TFV and RFV and enhances the uniformity as in a later-described embodiment. Generally, the belt ply includes at least one joint portion that is a joint at which both ends of the ply are jointed to each other in the molding process. This joint portion provides a primary vibration peak at the time of high speed rotation. However, if the first and second topping portions 12a and 12b having different rigidities are jointed each other and many joint portions are formed, the vibration peak is dispersed and the uniformity is enhanced.

[0019] In the belt ply, if the elastic modulus of the topping rubber is uniformly increased, the rigidity of the belt 7 can be increased but the riding comfort is deteriorated and noise is increased. Therefore, if the two kinds of rubbers having different elastic moduli are included in the topping rubber layer, the rigidity of the belt 7 can be enhanced without deteriorating the riding comfort and increasing noise. The hoop effect of the belt 7 is suitable for suppressing the variation of the FV component, and since the rigidity distribution of the belt ply is varied, there is an effect that the tire noise is reduced and the peak of a particular order component is reduced.

[0020] As shown in Fig. 4, according to this embodiment, the two belt plies 7A and 7B are radially arranged in the direction in which the belt cords 11 intersect with each other. Therefore, the two belt plies 9 and 9 having composite topping rubber layers 12 are overlapped in the direction in which the substantially parallelogram topping rubber portions 12a intersect with each other. With this, a new binding force is generated by a cross structure comprising the topping portions 12a and 12b, especially the second rubber Rb having greater complex elastic modulus. Thus, the rigidity as the belt 7 is further enhanced, and the vibration at the time of high speed running can be suppressed.

[0021] As shown in Fig. 2, the belt ply 9 of this embodiment is formed such that a length La of the first topping portion 12a in the circumferential direction of the tire measured at a side edge thereof in the widthwise direction of the ply, and a length Lb of the second topping portion 12b in the circumferential direction of the tire are substantially equal to each other. The first and second topping portions 12a and 12b are formed by parallelograms having the same shapes. According to such a topping rubber layer 12, since the distribution of rigidity is uniform, the uniformity can further be

enhanced.

[0022] The lengths L_a and L_b can be set in accordance with required performance. For example, when it is necessary to further enhance the rigidity of the belt ply 9, it is preferable that the length L_b of the second topping portion 12b is longer than the length L_a of the first topping portion 12a. When it is necessary to moderate the rigidity of the belt ply

9 on the other hand, the length L_b of the second topping portion 12b should be shorter than the length L_a of the first topping portion 12a. In any case, it is preferable that the lengths L_a and L_b are maintained constantly in one belt ply. **[0023]** In each belt ply 9 having the composite rubber layer 12, it is preferable that the number of first topping portion 12a and second topping portion 12b is 3 or more and 20 or less, more preferably 5 or more and 15 or less, and more preferably 5 or more and 10 or less. If the number is less than 3, the distribution degree of rigidity is small, and the enhancing effect of the uniformity is small. In some cases, there is an adverse possibility that the uniformity component becomes great. If the number exceeds 20 on the other hand, there is a tendency that the number of joint processes for jointing the first and second topping portions 12a and 12b is increased and the productivity is deteriorated. It is preferable that the length of the belt ply 9 is substantially an integral multiple of a sum ($L_a + L_b$) of the lengths L_a and L_b of the first and second topping portions 12a and 12b. The reason of the term "substantially" is that the overlapped portion of both ends of the plies is taken into account.

[0024] Although not particularly limited, it is preferable that a ratio (E^*/E^*) of complex elastic modulus E^* of the first topping rubber R_a and complex elastic modulus E^* of the second topping rubber R_b of the belt ply 9 is 1.15 or higher. If the ratio (E^*/E^*) is less than 1.15, the rigidity can not be dispersed effectively in the topping rubber 12, and there is a tendency that the uniformity can not be enhanced. It is more preferable that the ratio (E^*/E^*) is 1.2 or higher. On the other hand, if the ratio (E^*/E^*) is excessively high, the rigidity difference between the first and second rubber R_a and R_b becomes excessively large, stress concentration is prone to be generated in the joint interface of both the rubbers, and there is a tendency that the durability is deteriorated. Due to such reasons, it is preferable that the ratio (E^*/E^*) is not more than 1.50 and more preferably not more than 1.40. More specifically, the complex elastic modulus of the first topping rubber R_a is preferably about from 5.0 to 8.0 MPa.

[0025] In this specification, the complex elastic modulus is a value obtained by measuring a measurement sample using a viscoelasticity spectrometer "VES F-3 type" made by Iwamoto Seisakusho under the following conditions:

Measuring temperature: 70°C

Frequency: 10 Hz

Initial extension distortion: 10%

Half amplitude: 1%

[0026] The belt ply 9 having the composite topping rubber layer 12 can be produced using equipment or process as shown in Fig. 5. In Fig. 5 shows a central conveyor C_c , a first ply piece supply conveyor C_a disposed on one side of the central conveyor C_c , and a second ply piece supply conveyor C_b disposed on the other side. The first ply piece supply conveyor C_a successively supplies, toward the central conveyor C_c , first topping rubber ply pieces 20a obtained by bias-cutting a base ply (not shown) coated with the first rubber R_a . The second ply piece supply conveyor C_b successively supplies, toward the central conveyor C_c , second topping rubber ply pieces 20b obtained by bias-cutting a base ply (not shown) coated with the second rubber R_b . In the central conveyor C_c , the first and second ply pieces 20a and 20b which are alternately supplied are pressed and jointed, thereby continuously forming the long belt plies 9 having the composite topping rubbers. This is one example of the producing method, and the method is not limited to this only.

[0027] Fig. 6 shows another embodiment of the present invention. Fig. 6 corresponds to a sectional view taken on line A-A in Fig. 2. In the topping rubber layer 12 of this embodiment, only one surface of the belt cords 11 is made of two kinds of topping rubbers R_a and R_b , and the other surface is made of one kind of topping rubber (e.g., first rubber R_a). In this manner, the present invention can be carried out in various modes.

[0028] Although the embodiments of the present invention have been described above, the invention is not limited to these embodiments. For example, the topping rubber may be formed of three or more kinds of topping rubbers having different complex elastic moduli. In this case, three kinds of rubber materials are alternately arranged in the same order in the circumferential direction of the tire.

EXAMPLES

[0029] To confirm the effect of the present invention, pneumatic radial tires (tire size: 215/60R16 95H) were prototyped based on the specification shown in Table 1, and uniformity was tested. In the measurement of uniformity, TFV and RFV were measured in accordance with uniformity testing conditions of JASO C607:2000 using a uniformity tester. The evaluation speed is 120 km/h. This is because that TFV which is prone to have a problem as the running speed is increased is evaluated. A result is expressed using the average value (N) of twenty tires. The smaller the numeric

value, the better the result is. Table 1 shows the test result and the like.

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Table 1

	Conventional Example	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
First topping portion	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	-	10	7	3	2	12	1	10	10	10
	-	100	143	333	500	83	1000	100	120	80
Second topping portion	-	7.8	7.8	7.8	7.8	7.8	7.8	7.2	7.8	7.8
	-	10	7	3	2	12	1	10	10	10
	-	100	143	333	500	83	1000	100	80	120
Test result	TFV	80	78	81	80	82	80	78	78	76
	Primary [N]									
	Secondary [N]	64	68	73	72	80	88	81	66	62
(E*b/E*a)	Tertiary [N]	43	41	41	40	43	48	43	41	42
	RFV	80	79	77	81	81	77	81	80	79
	Primary [N]									
	-	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.2	1.2

[0030] As a result of the test, it could be confirmed that the example tire of the present invention has smaller TFV and RFV and more excellent uniformity as compared with the conventional example.

Claims

1. A pneumatic tire comprising:

a carcass extending between bead portions through a tread portion and sidewall portions; and
a belt disposed radially outside the carcass in the tread portion, said belt comprising
at least one belt ply made of parallel cords embedded in a composite topping rubber layer,
said composite topping rubber layer formed at least two kinds of topping rubbers having different complex
elastic moduli and
said topping rubbers alternately disposed in a circumferential direction of the tire.

2. A pneumatic tire according to Claim 1, wherein

the composite topping rubber layer comprises
a first topping portion made of a first topping rubber and
a second topping portion made of a second topping rubber having greater complex elastic modulus than that
of the first topping rubber.

3. A pneumatic tire according to Claim 2, wherein

the parallel cords of the belt ply are inclined with respect to the circumferential direction of the tire, and
each of the first topping portion and the second topping portion are formed into substantially parallelogram
having a pair of parallel sides extending along the cords.

4. A pneumatic tire according to Claim 1 or 2, wherein

the belt comprises at least two belt plies arranged in a direction in which the cords intersect with each other,
and
each of the belt plies has the composite topping rubber layer.

5. A pneumatic tire according to Claim 2 or 3, wherein

a length of the first topping portion in the circumferential direction of the tire substantially equals to a length
of the second topping portion in the circumferential direction of the tire.

6. A pneumatic tire according to Claim 2 or 3, wherein

each belt ply having the composite topping rubber layer includes from 3 to 20 first topping portions and
second topping portions.

7. A pneumatic tire according to Claim 2 or 3, wherein

a ratio (E^2/E^1) of complex elastic modulus E^1 of the first topping rubber and complex elastic modulus E^2
of the second topping rubber is from 1.15 to 1.50.

FIG.1

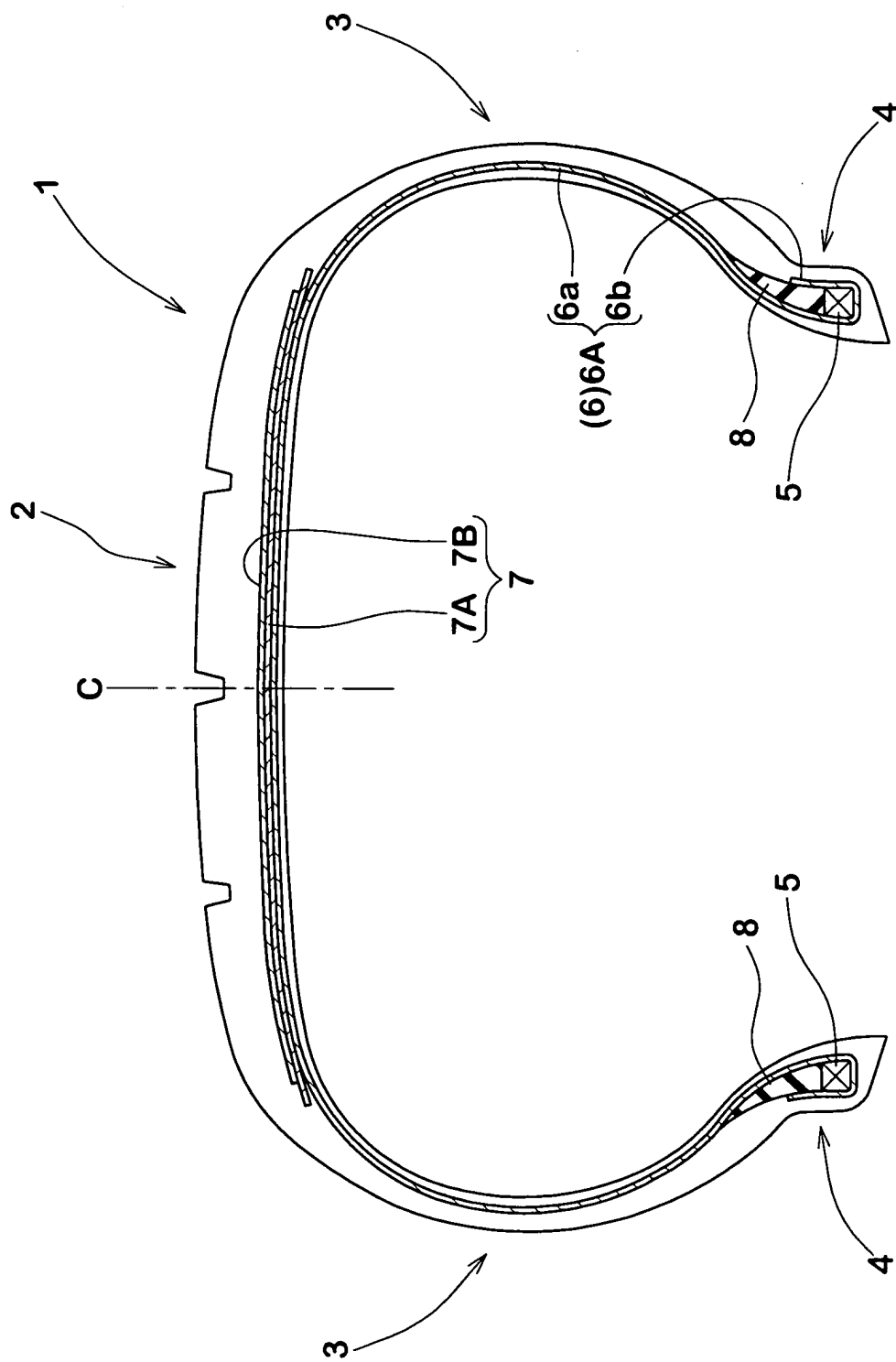


FIG.2

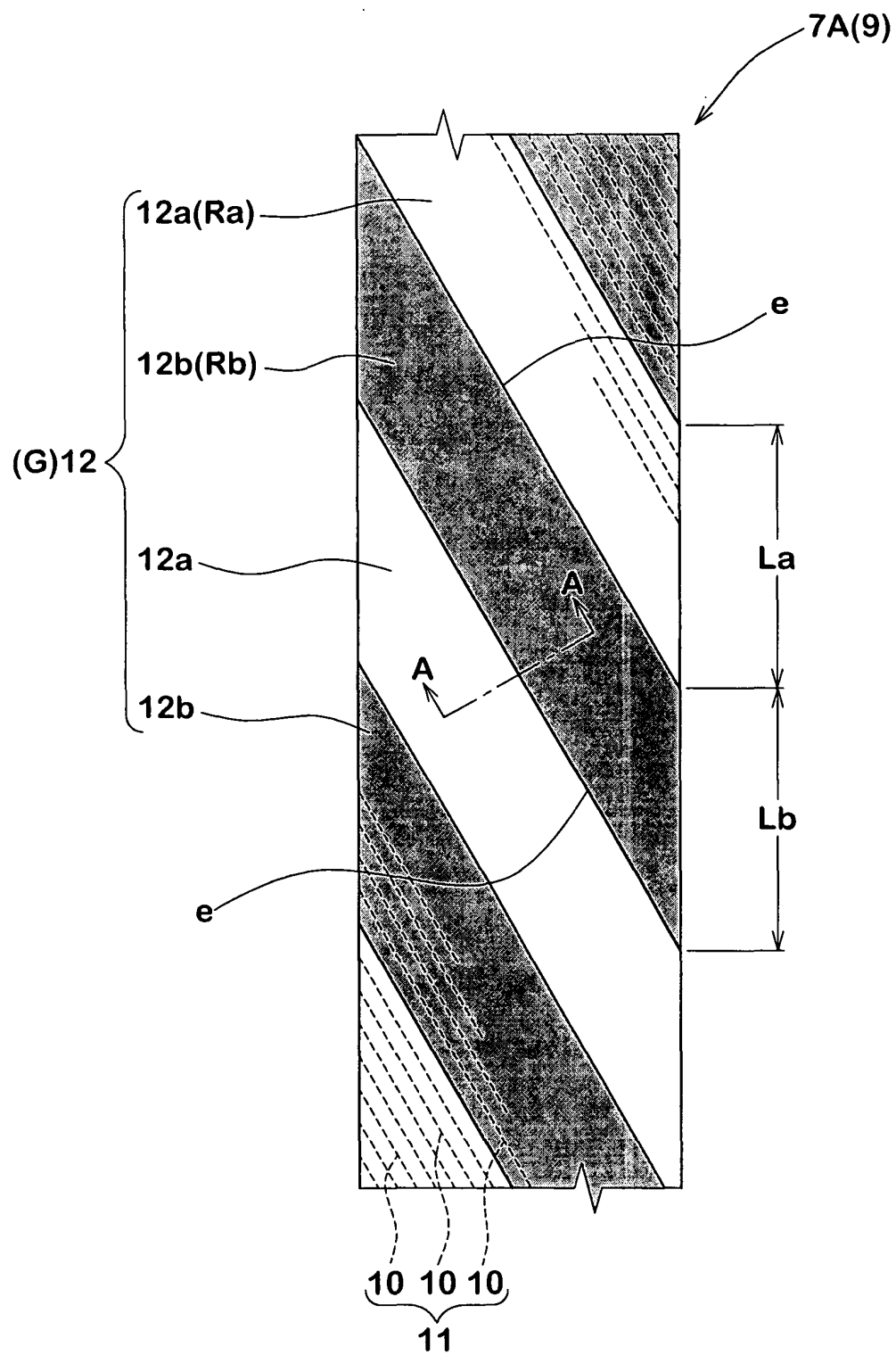


FIG.3

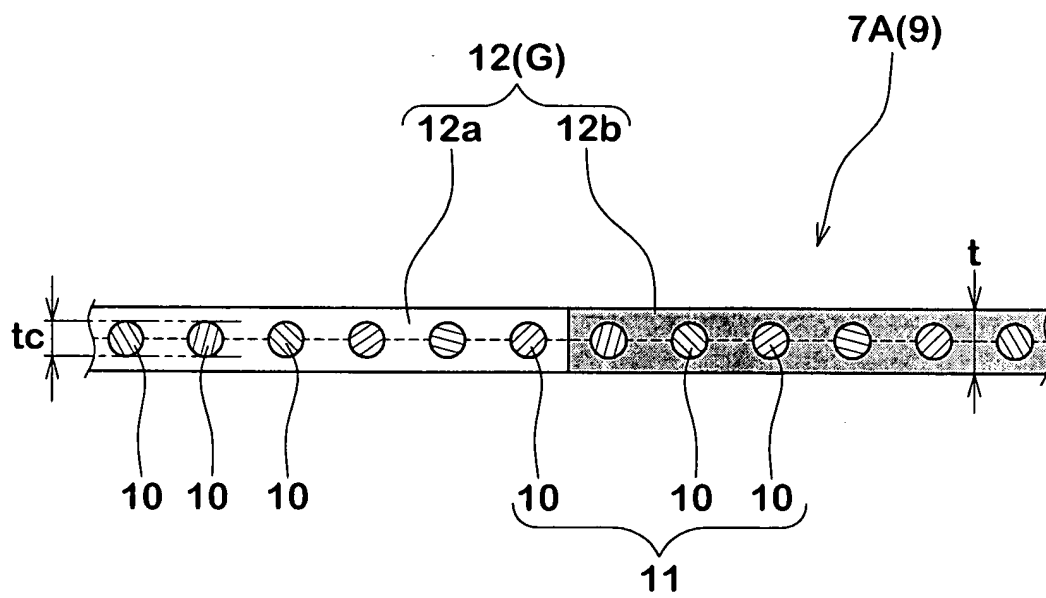


FIG.4

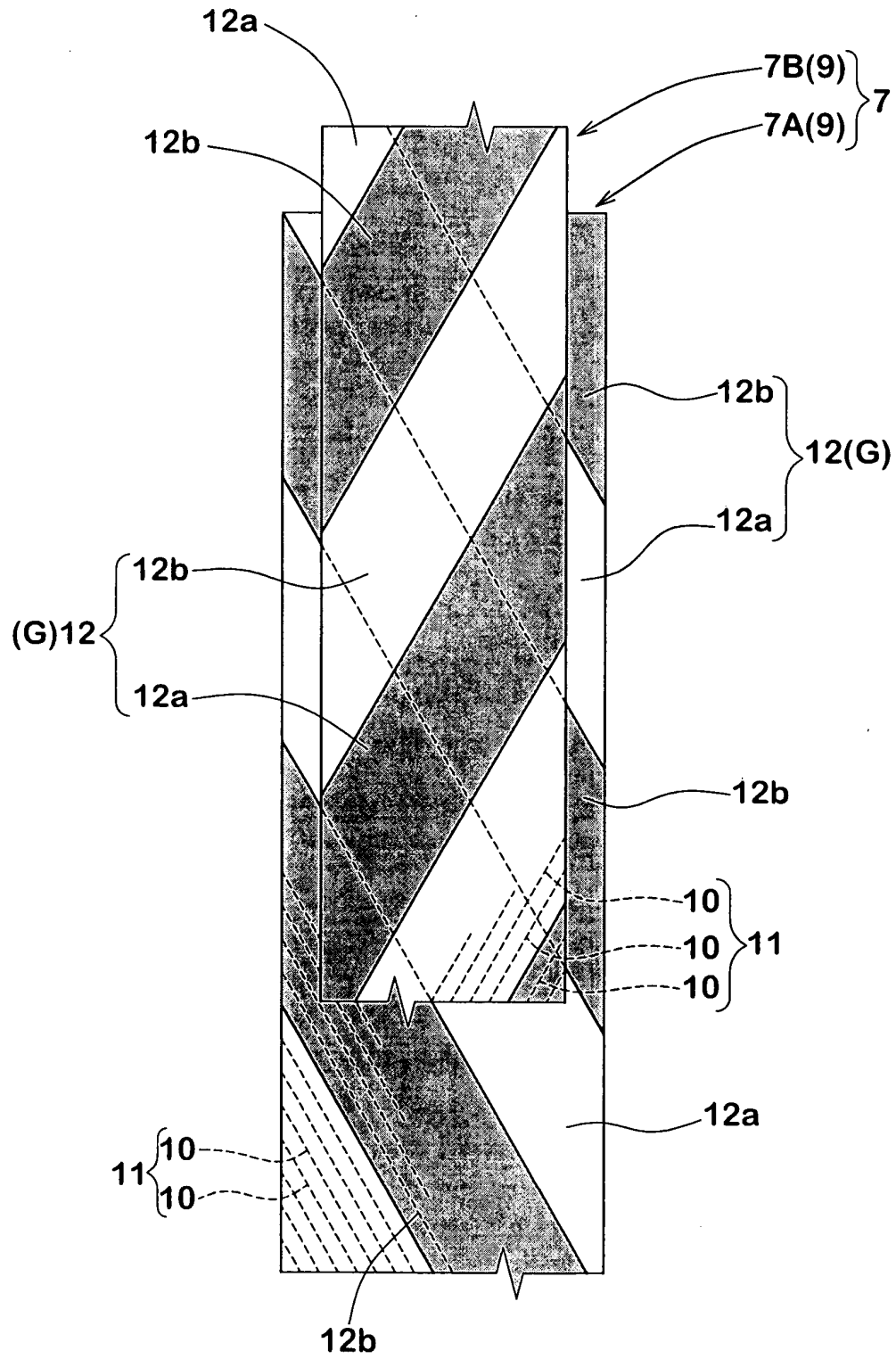


FIG.5

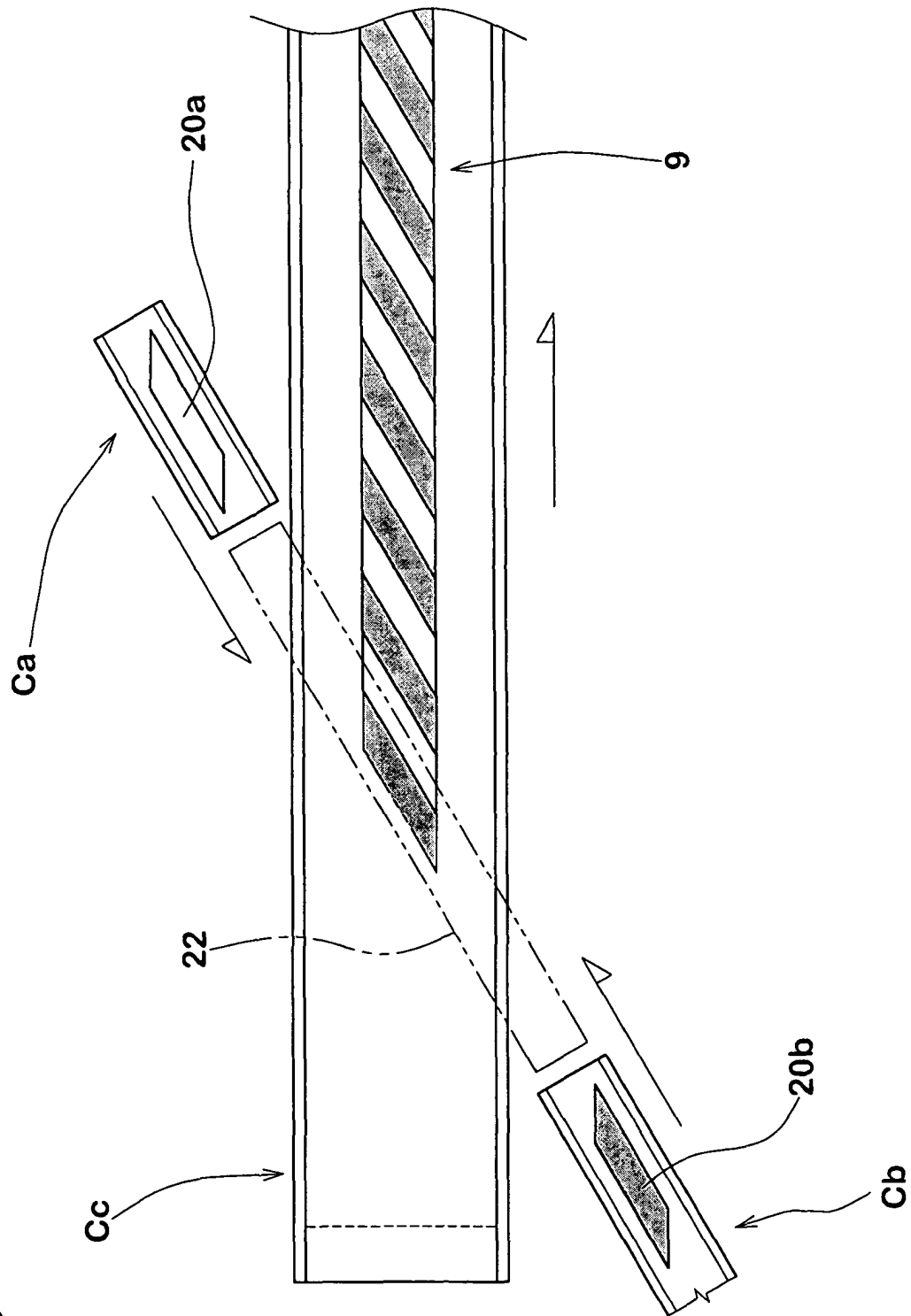
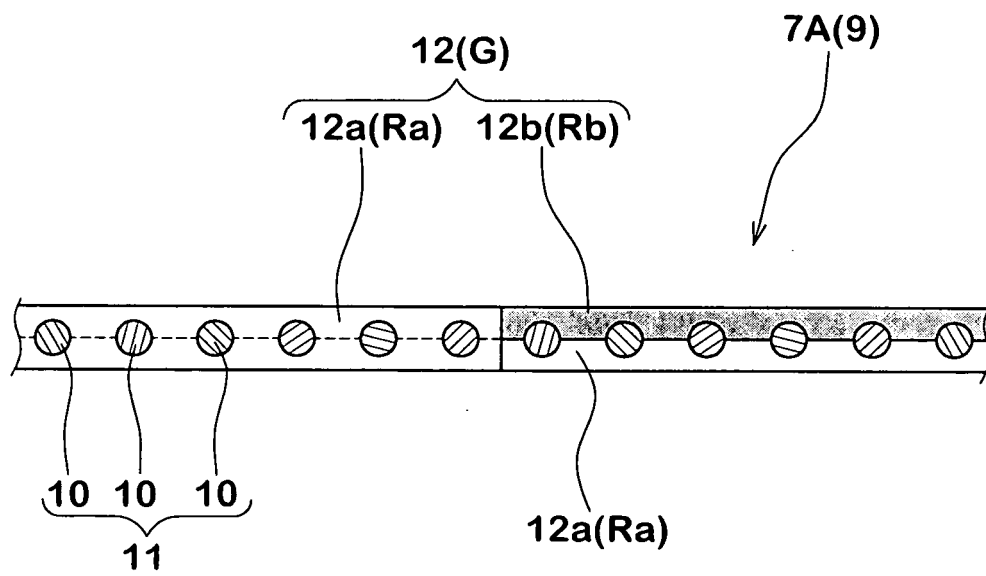


FIG.6



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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 00 2185

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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24-06-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2003226113 A	12-08-2003	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82